Design for Biosecurity

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Lecture 6

History of Bioterrorism : Black Death

Welcome back to the second week of our course. In our last class, we introduced the concept of bioweapons and the various categories of bioterrorist agents. These were classified into Class A, Class B, Class C, and so on, depending on factors such as their severity, their ability to infect, and how easily they can spread. Today marks the beginning of the second week, and this is our sixth lecture. In this session, we will delve into the historical perspective of biowarfare.

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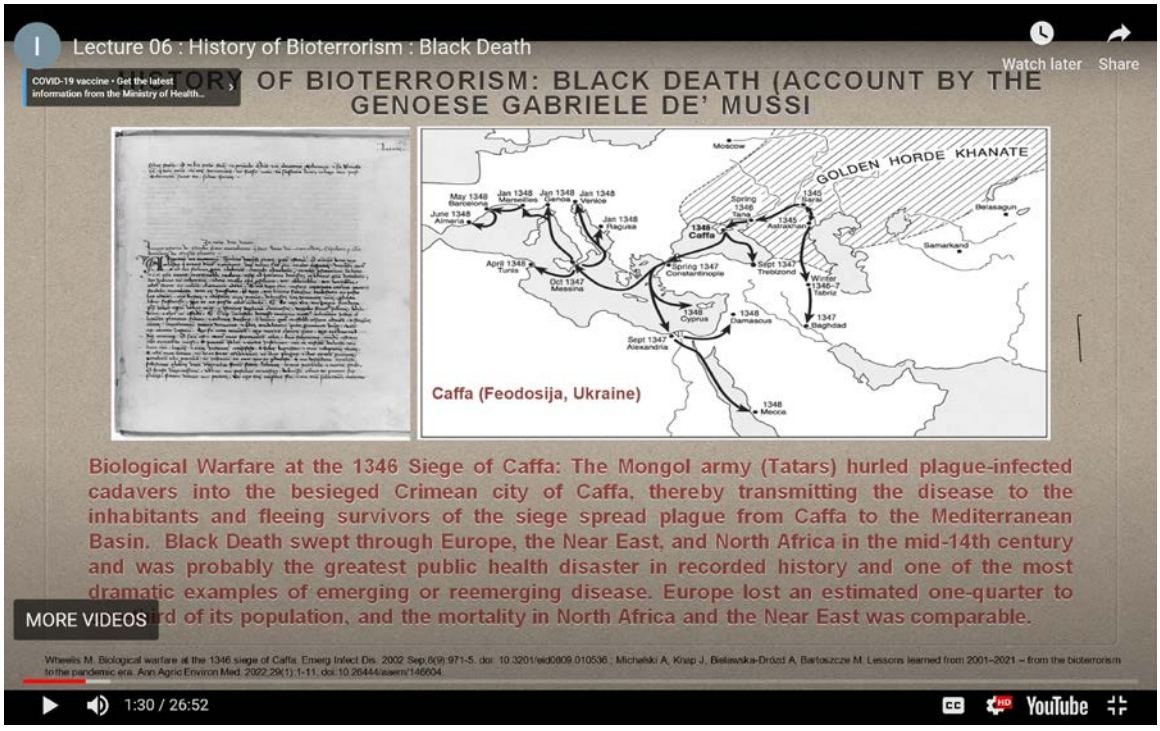

Many of us tend to think that biowarfare is a modern phenomenon, but the truth is, it has been around much longer than we might imagine. In fact, written evidence of biowarfare

dates back as far as the 13th century. While there may have been instances of biowarfare before this time, the documentation is limited, though we do find some anecdotal evidence scattered throughout history.

Today, we will start by exploring one of the most infamous incidents of biowarfare, an event where humanity, perhaps unknowingly, wielded microbial weapons. This event dates back to 1346, during the siege of Caffa.

Before we dive into the details of this siege, let me give you a brief overview of what transpired. There were two warring factions, one of which had taken refuge inside a fortified city, while the other laid siege from outside. In a grim twist, the attacking faction resorted to a brutal tactic, they hurled dead bodies, specifically cadavers, into the city. Now, the records are somewhat unclear about how many cadavers were used and exactly how they were deployed, but the intention was clear: to force the defenders out of their stronghold. The idea was that the decomposing bodies would create an unbearable stench, ultimately driving the people inside the fort to abandon their positions.

At the time, historians believed this strategy was meant to work solely through the foul smell produced by the decaying bodies. However, the reality turned out to be far more sinister. This event spiraled into a catastrophe of unimaginable proportions. What they had unknowingly unleashed was not just a malodorous nightmare but a deadly plague, the Black Death.

Now, let's talk about the siege of Caffa. You might be wondering, where exactly is Caffa? Today, this location is known as Feodosiya, a city in modern-day Ukraine. Interestingly, this region is currently involved in ongoing conflict, which further highlights its historical significance.

During this siege, Caffa became the site of one of the earliest recorded instances of biological warfare. We are fortunate to have a historical account of this event, documented by a Genoese writer named Gabriel de Mussi. De Mussi's account, originally written in Latin (and perhaps other languages), was eventually translated into English after many years, allowing us to better understand the tragedy that unfolded there.

The Black Death, as many of you are likely aware, refers to a devastating plague epidemic that swept across Europe. This incident at Caffa is often cited as one of the key moments in the spread of the plague. The people of the besieged city were exposed to the disease through the infected cadavers that were catapulted into their midst.

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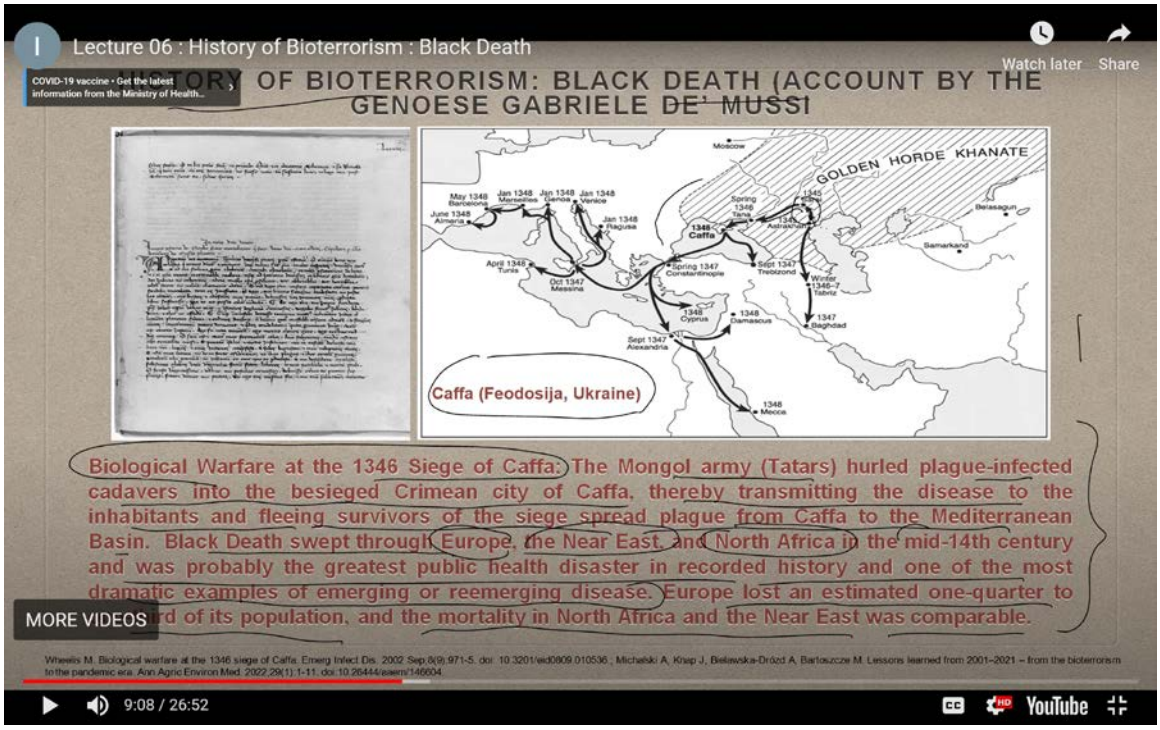

Now, to better understand this event, let's take a closer look at Caffa. As I mentioned earlier, Caffa is located in present-day Ukraine, and this war took place in that very region around 700 years ago. The implications of this siege, and the role it played in spreading one of the deadliest pandemics in human history, cannot be overstated.

In the upcoming slides and discussions, we will delve deeper into the history of bioterrorism, focusing specifically on the Black Death and Gabriel de Mussi's account of this horrific event. This historical example underscores the profound impact that biological warfare can have on societies, economies, and civilizations as a whole. It also serves as a reminder of why it is so crucial to study these phenomena, understand them thoroughly, and be vigilant in our efforts to prevent such catastrophes from occurring in the future.

If you follow the bold arrows on the map, you'll see how the spread of this plague infection unfolded. It originated in one region and steadily expanded, engulfing the entire continent of Europe, and even crossing borders into distant lands across the globe. If you look closely, you'll notice that it spread all the way from the Caspian Sea, extending far beyond to parts of Europe, North Africa, and the Near East.

To put this into context, in 1346, during the siege of Caffa, one of the warring factions was the Mongol army, also referred to as the Tatars. During this conflict, the Mongols, unaware of the full implications of their actions, catapulted plague-infected cadavers into the besieged Crimean city of Caffa. While their intention was likely to create havoc and fear among the city's inhabitants, they inadvertently triggered the spread of the plague. As fleeing survivors carried the infection with them, it radiated outwards from Caffa to the Mediterranean basin, and ultimately, the Black Death ravaged Europe, the Near East, and North Africa during the mid-14th century.

This outbreak is widely regarded as the most significant public health catastrophe in recorded history and serves as a profound example of the devastating impact of emerging and re-emerging diseases. Europe lost an estimated one-quarter to one-third of its population, with North Africa and the Near East experiencing similarly devastating mortality rates. The epidemic reached countries such as Italy, Portugal, and Spain, while across the Mediterranean, regions like Algeria and Morocco in North Africa were also heavily affected.

This pattern of contagion highlights a crucial point: whenever a population encounters a novel pathogen, one for which it has no immunity, the likelihood of devastation is high. History has repeatedly shown us this truth. For instance, during the recent COVID-19 pandemic, we witnessed how a novel virus, to which the global population had little to no immunity, swept across nations at an alarming pace. From its origin in China, the virus rapidly crossed borders, even traversing vast oceans to reach distant places like the United States. Modern travel, combined with the global exchange of goods, animals, and plants, facilitates such rapid transmission.

If a biological attack similar to the 1346 siege of Caffa were to happen today, the consequences would be far more severe due to the speed and scale of global movement. We saw this firsthand during the COVID-19 pandemic, before countries could fully grasp the situation, the virus had already spread across the world. Infections crossed seas, reached remote locations, and continued to spread exponentially. The challenge with such pathogens is that we cannot quarantine what we do not know. Quarantines are only effective for diseases that are known and understood. However, when a new pathogen emerges, its initial symptoms often resemble more common illnesses like the flu, coughing, sneezing, and so on, meaning by the time it is fully recognized as a threat, it may be too late to contain its spread.

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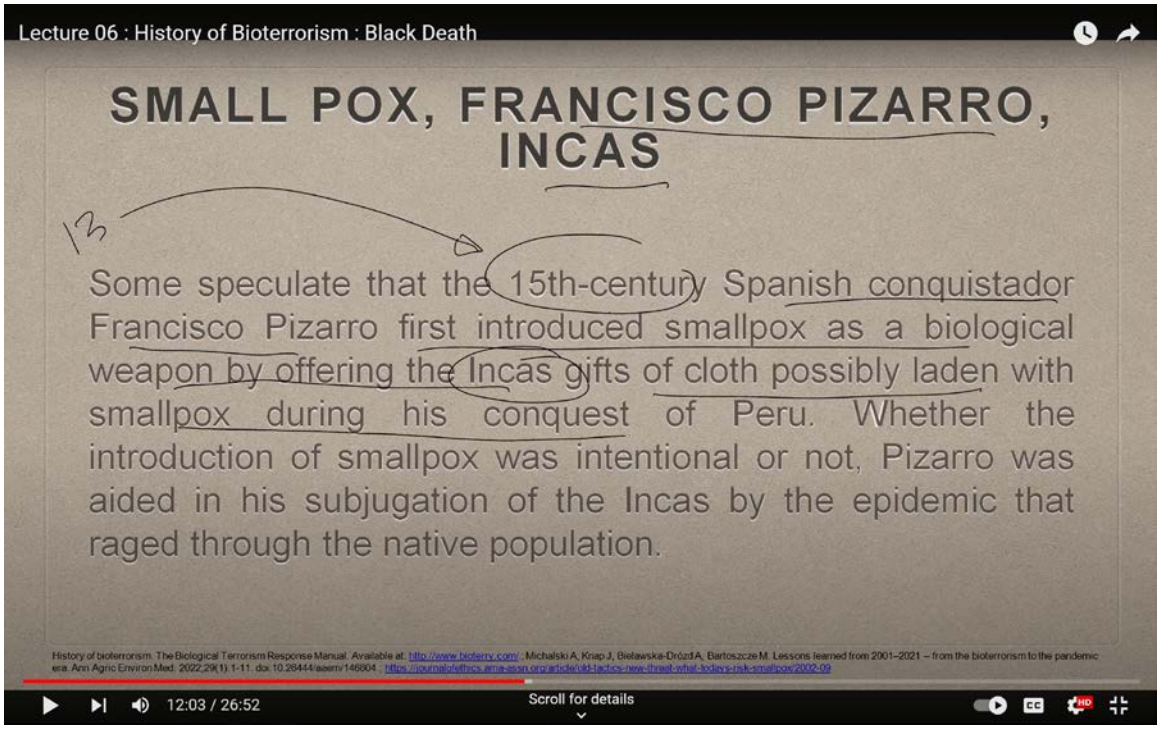

This map shows us just how dramatically a pathogen can spread. Some 700 years ago, the Black Death wiped out a significant portion of the population across Europe, North Africa, and beyond. Events like this inspire us to learn more about how infections travel across geographical spaces and recur over time. Many pathogens don't just disappear; they may go into hiding, lying dormant in what we call hibernation. Take COVID-19 as an example:

just because we've managed to slow its spread doesn't mean it won't resurface. There may still be silent carriers of the virus, waiting for the right conditions to trigger another outbreak.

This phenomenon isn't unique to COVID-19. In tuberculosis (TB), people can be silent carriers of the disease, showing no symptoms but still harboring the pathogen. Under the right circumstances, such as when their immune systems are compromised, the disease can flare up again. This happens frequently with patients who suffer from AIDS; while AIDS doesn't kill them directly, it weakens their immune systems, making them vulnerable to other microbial attacks like TB or other infections.

This pattern is how many pathogens operate, they exploit weaknesses in the body's defenses. As we continue our historical exploration of bioterrorism, we'll move on from the horrors of 1346 to another infamous pathogen, smallpox, which also posed a terrifying threat to humanity.

The story of smallpox as a biological weapon is even more intriguing than previous examples. In the case we discussed earlier, plague-infected cadavers were used to decimate a population. However, the smallpox incident unfolded in a far more subtle and devious manner, through the gifting of infected blankets. Let's delve into the details.

Moving forward in history to the 15th century, we encounter Francisco Pizarro and his interactions with the Incas, the indigenous population of Latin America and the architects of the historical Incan civilization. During Pizarro's conquest of Peru, there is speculation that smallpox was introduced as a biological weapon, possibly through gifts of clothing contaminated with the virus. While it's unclear whether this introduction of smallpox was deliberate, it's evident that the resulting epidemic greatly aided Pizarro in subjugating the Incas. This scenario mirrors the siege of Caffa, where it remains uncertain whether those involved fully understood the deadly implications of their actions.

Now, moving on to smallpox as a bioweapon, we find the first well-documented use of this virus by British troops during the French and Indian Wars in 1763. Here, the narrative becomes even more chilling. Captain Equer of the Royal Americans presented two blankets

and a handkerchief, all contaminated with smallpox, as a gift to the Native Americans. Four years later, British General Sir Geoffrey Amherst continued this practice, distributing more infected blankets to Native Americans allied with the French. The result was devastating, up to half of the population in the affected tribes perished.

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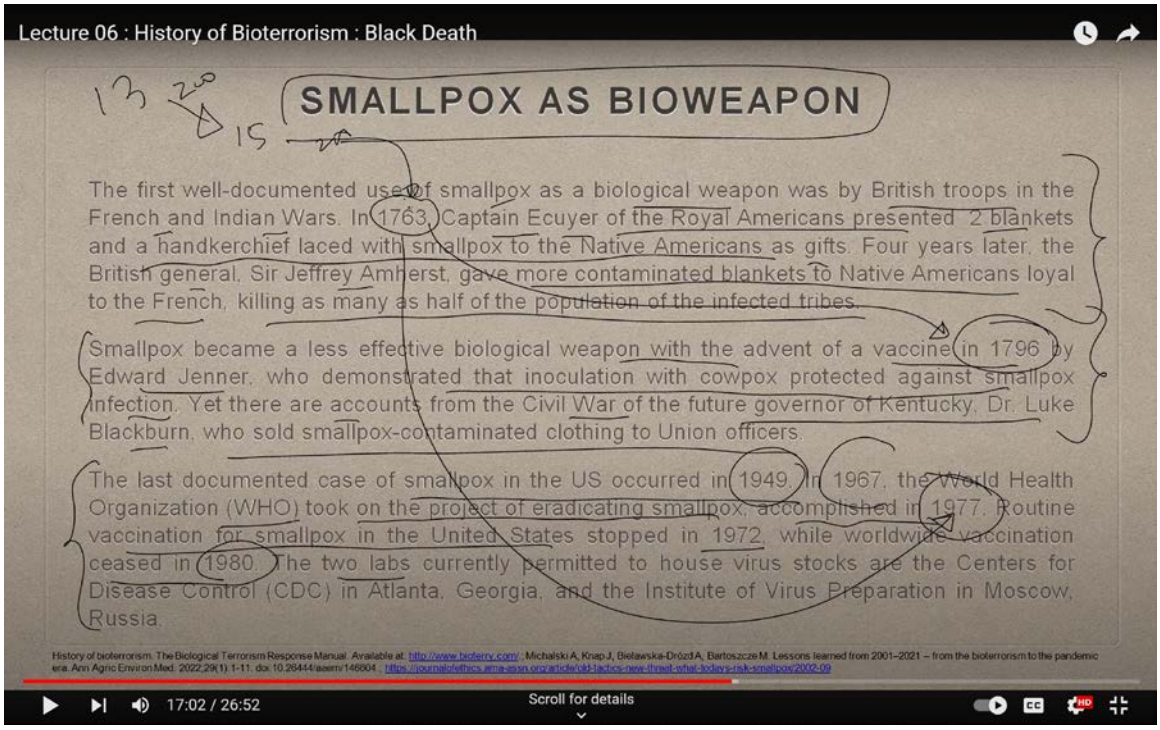

This brings us back to the novel weapon hypothesis I mentioned earlier: when a population is exposed to a new pathogen, especially one they have no prior immunity against, it can wreak havoc on their immune system. Our bodies are constantly at war with familiar microbes, creating a delicate balance. This is why, for common illnesses like the cold, doctors sometimes advise against medication, allowing the body to fight off the infection naturally. However, when an entirely new and unfamiliar pathogen is introduced, it can act as a novel weapon, overwhelming the immune system and leading to widespread devastation.

The effectiveness of smallpox as a biological weapon began to wane with the advent of vaccination in 1796. This marked a turning point in human history, thanks to Edward

Jenner, who demonstrated that inoculation with cowpox could protect against smallpox infection. Jenner's discovery was monumental, laying the foundation for vaccines as a means to counter biological threats. Despite this progress, there are accounts from the Civil War that show smallpox was still used as a weapon. For instance, Dr. Luke Blackburn, who later became the governor of Kentucky, is known to have sold smallpox-contaminated clothing to Union officers.

The year 1796 stands as a landmark in medical history, marking the discovery of the first vaccine and providing humanity with a powerful tool to combat biological weapons. Edward Jenner's work not only revolutionized medicine but also offered a glimpse of hope in the ongoing battle against infectious diseases.

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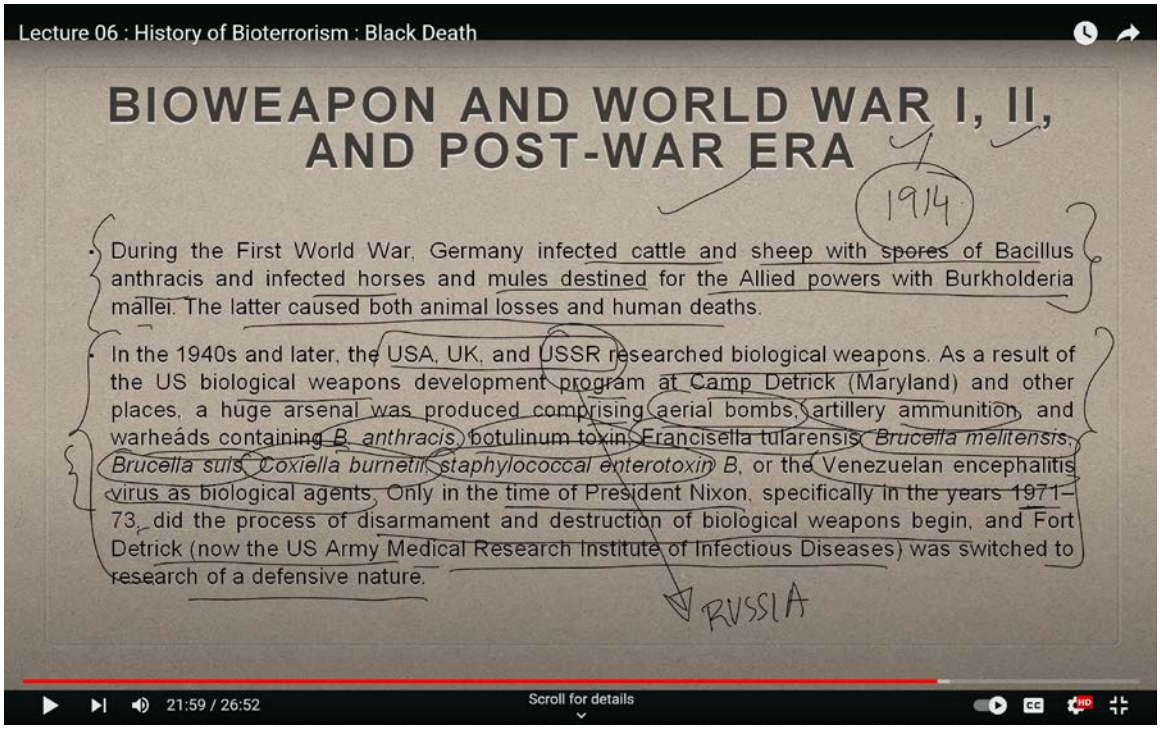

The first significant milestone in safeguarding biosecurity can be traced back to 1796, marking one of humanity's earliest efforts to protect populations from deadly pathogens. This was the year that Edward Jenner introduced the first vaccine in history, which offered protection against smallpox. If you think about it, this was the dawn of an ongoing battle

that continues to this day, one that reached new heights recently with the development of COVID-19 vaccines. From Jenner's time in 1796 to 2024, it’s been nearly 230 years of gradually evolving measures to counteract various biological threats.

To put this into perspective, smallpox was a deadly disease for centuries, but humankind's relentless efforts against it culminated in its eradication. The World Health Organization (WHO) embarked on a global campaign to eliminate smallpox in 1967, succeeding by 1977. The last documented case of smallpox in the U.S. occurred in 1949, and routine vaccinations in the country stopped in 1972, with worldwide efforts ceasing by 1980. However, to this day, there are two laboratories globally that are authorized to store the virus: the Centers for Disease Control (CDC) in Atlanta, Georgia, and the Institute of Virus Preparation in Moscow, Russia.

These virus stockpiles serve a strategic purpose. While stockpiling vaccines for every potential pathogen isn't feasible due to cost and limited shelf life, retaining the actual bioweapons, such as smallpox, ensures that, should an outbreak reoccur, scientists can quickly develop an antidote. However, there’s a significant risk. If these biological agents fall into the wrong hands, they could be weaponized. This is why there are strict international regulations about which countries and institutions can house such dangerous pathogens. While most of these stockpiles are documented, the real challenge lies in controlling those that aren't.

Now, turning our attention to the use of bioweapons during wartime, World War I offers an early example of biological warfare. During this conflict, Germany infected cattle and sheep destined for Allied forces with Bacillus anthracis (the bacteria responsible for anthrax) and horses and mules with Burkholderia mallei, which caused glanders, a disease that resulted in significant animal losses and human fatalities. This was during the period of 1914 to 1917, more than a century ago, when livestock played a crucial role in military operations. Horses were especially vital for artillery and transportation, and Germany strategically deployed these bioweapons to weaken the enemy’s logistical capabilities by wiping out their livestock.

Even after World War I, the development and use of biological weapons continued. By the 1940s, the United States, United Kingdom, and USSR had invested heavily in biological warfare research. The U.S. launched the Biological Weapons Development Program in Cambridge, Maryland, where they developed a substantial arsenal, including aerial bombs, artillery shells, and warheads loaded with a variety of biological agents. Among these were Bacillus anthracis, botulinum toxin, Francisella tularensis, Brucella suis, staphylococcal enterotoxin B, and even Venezuelan encephalitis virus. These bioweapons were designed to spread deadly pathogens through aerosol or physical contact, making them potent tools of war.

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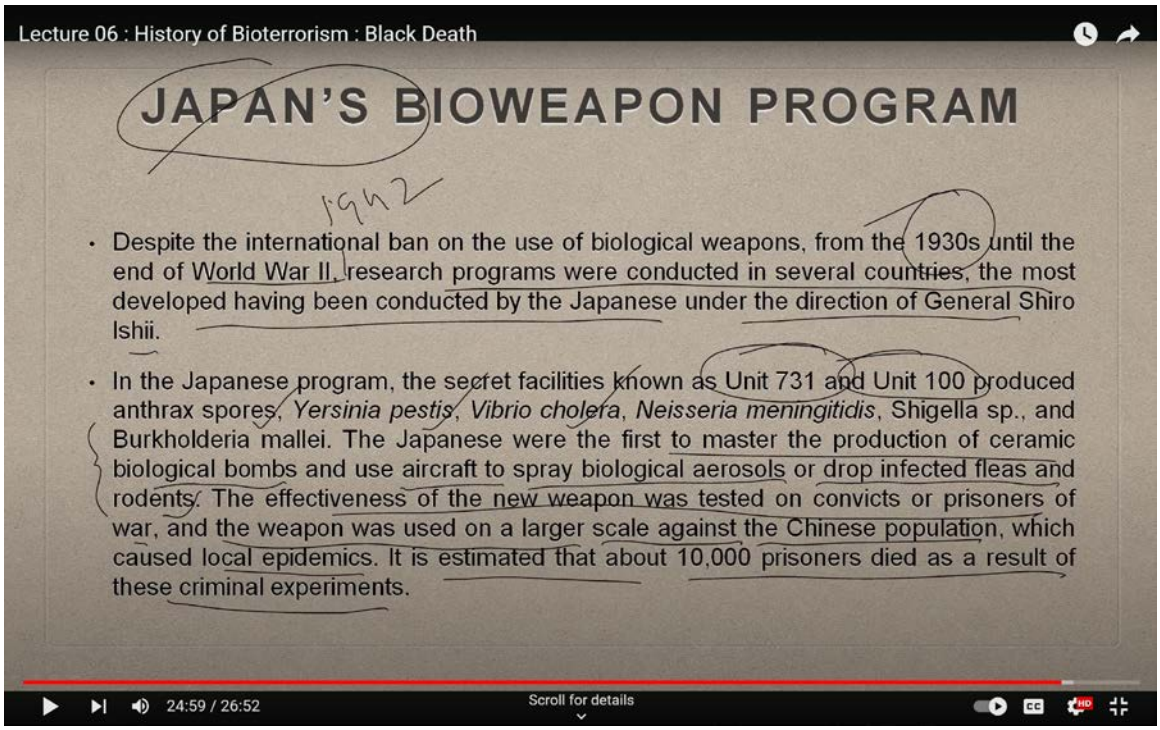

The tide began to turn in the early 1970s, when President Nixon initiated the process of biological disarmament in the U.S., leading to the destruction of biological weapons stockpiles at Fort Detrick. The facility, once a hub for bioweapons research, was repurposed into the U.S. Army Medical Research Institute of Infectious Diseases, focusing on defensive rather than offensive measures. This period of disarmament, from 1971 to 1973, coincided with a pivotal moment in global politics, the collapse of the USSR. When

the Soviet Union fragmented into multiple independent states, its vast arsenal of bioweapons became a significant concern. The bioweapons were dispersed across various regions, and the challenge of securing them became more complicated, particularly during the political upheaval of perestroika and glasnost.

Imagine a situation where a nation breaks into several independent states, each state now an autonomous country. Coordination between them becomes an enormous challenge, especially in the chaos that follows such fragmentation. In this type of disarray, it's nearly impossible to predict who will seize power and where, which leaves bioweapons dangerously vulnerable to falling into the wrong hands. This was precisely the fear after the collapse of the USSR. Their vast biowarfare program became a significant cause for international alarm, as many of their bioweapons were unaccounted for, leading to concerns about where they might eventually surface.

While the disintegration of the USSR brought significant instability, another country on the other side of the world had long been ahead in the development of biological weapons, Japan. Japan's biowarfare program dates back to the 1930s, and despite international bans on biological weapons, Japan pushed forward with its research, particularly during the lead-up to World War II. At the helm of this program was General Shiro Ishii, who oversaw a secret operation at facilities known as Unit 731 and Unit 100.

The Japanese program was extraordinarily advanced for its time. They produced deadly agents such as anthrax spores, Yersinia pestis (the bacterium responsible for plague), Vibrio cholerae (which causes cholera), Neisseria, Shigella, and Burkholderia mallei. Perhaps more disturbingly, the Japanese were pioneers in the development of ceramic biological bombs. They even used aircraft to spread biological aerosols and dropped infected fleas and rodents, leading to devastating consequences.

The efficacy of these bioweapons was tested on prisoners of war and convicts, with an estimated 10,000 prisoners losing their lives to these horrific experiments. Japan also deployed these weapons on a larger scale against the Chinese population, which resulted in local epidemics. Japan's biowarfare program exemplifies how biological weapons were an integral part of global military strategies during the last century.

While most conversations about World War II and the subsequent Cold War focus on nuclear arms, a quieter but equally dangerous race was taking place, the race for biological weapons. And while launching a nuclear warhead requires complex operations, launching a biological warhead is far easier and perhaps more dangerous in certain contexts.

Japan's technological prowess in biowarfare remained unmatched until its defeat at the end of World War II. However, after Japan's downfall, its knowledge and innovations in biological warfare spread to other global powers, including the United States, the USSR, and the United Kingdom. This proliferation of knowledge marked the beginning of a new era in the biological arms race.

In the next class, we will delve deeper into how these other nations picked up where Japan left off and further advanced the field of biological warfare. Thank you for your attention.